Office of the Chief Scientist for Human Factors

Flight Technologies and Procedures

Program Review
FY02

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The Federal Aviation Administration Office of the Chief Scientific and Technical Advisor for Human Factors (AAR-100) directs research to address new technologies, procedures, or capabilities that cut across several operational environments, e.g., air carriers, regional airlines, and general aviation. Examples of research in this area include: development of a Job Aid for use by certification personnel (and designers) to identify and address human factors issues during the aircraft certification process; development of human factors considerations in the design and evaluation of electronic flight bags (EFBs); development of recommendations for cockpit head motion box size for head-up displays used in civil transports and general aviation.

The following report lists projects between October 1st, 2001 and December 31st, 2002 (Appendix I). These projects address requirements identified by the Federal Aviation Administration Certification office (Appendix II). The intent of this report is to allow Federal Aviation Administration sponsors to determine whether their requirements have been satisfactorily addressed, allow investigators to receive feedback from Federal Aviation Administration sponsors and other interested parties, and to provide feedback to the AAR-100 aviation maintenance program manager on the quality of the research program. Basically, this document is a means of holding each group (sponsor, investigator, AAR-100 program manager) accountable to ensure that the program is successful.

In FY02, the Flight Technologies and Procedures research program distributed $ 1,600,000 contract and grant dollars to multiple organizations. These FY02 projects are described in Appendix I and the requirements that are mapped to these projects are located in Appendix II.

Appendix III lists the FY03, FY04, and FY05 funded projects.

Address questions or comments to:

To view projects, pages 3-19

To view requirements, pages 20-66

To view FY03-FY05 proposed projects, pages 67-70

Thomas McCloy, Ph.D.

Appendix I

Flight Technologies and Procedures

FY02 Funded Projects

Primary investigators submitted project summaries via world-wide-web. A newly created interactive web-based system modeled after the Office of Naval Research and the National Science Foundation was developed to standardize the yearly report submitted to the Office of the Chief Scientist for Human Factors. The reporting system can be found at http://www.hf.faa.gov/report

Project Title: *Electronic Flight Bag*

Primary Investigator: E. Donald Sussman, USDOT Volpe Center, Cambridge, MA

Co-Primary Investigator: Divya Chandra, USDOT Volpe Center, Cambridge, MA (email: chandra@volpe.dot.gov)

FAA Sponsor Organization: AIR-130 (POC: Colleen Donovan)

Sponsor's Requirement Statement: to provide certification (AIR), operational approval, and training (AFS) guidance, including input to AC's, as well as to mitigate risks associated with the implementation and integration of electronic flight bags on the flight deck.

Research Project's Goal: The Volpe EFB human factors document will also be the basis for developing a procedure for a human factors field evaluation of EFBs. The field evaluation procedure will be designed for use by personnel who are not human factors experts. Volpe will collect data on how well different procedures for evaluating EFBs work. Usability experts will first perform reviews. Then, subjects (who take on the role of a regulator) will run sample tests on vendor-provided EFBs. The subjects' usability evaluations will be compared against the experts' evaluation. We expect to identify a set of tests that are easy to administer, highly diagnostic of usability issues, and comprehensive.

Version 1 of this document was both a reference and source of material for human factors guidance in the current EFB AC. Material from the Version 2 document will be incorporated into a revision of the EFB AC, which will be issued in January 2003.

Best Accomplishment: A draft of *Human Factors Consideration in the Design and Evaluation of EFBs, Version 2.0* was released for comment on 6 September 2002 to industry and FAA. Industry comments and material from the July 2002 EFB Advisory Circular was incorporated into this document, and a chapter on Electronic Charts was fleshed out. The results of a formal issues and requirements analysis were incorporated into the Electronic Charts chapter.

Project Summary: There is currently great interest in developing electronic information management devices for use by pilots in performing flight tasks. These devices are called "Electronic Flight Bags" (EFBs). EFBs typically consist of a screen and controls in a self-contained unit that is relatively small, weighing only a few pounds at most. EFBs can be hand-held portable devices or mounted in the flight deck. They are less expensive and more flexible than traditional avionics, and have a wide range of functionality. They may be passive display or interactive, and can stand-alone or connect to on-board and/or ground systems. They were originally seen as a repository for electronic documents such as checklists, operating manuals, and navigation publications. In the future, many airlines envision that EFBs may become multi-function devices supporting an

array of applications beyond those of a traditional flight bag, from electronic messaging to display of live weather.

The Federal Aviation Administration (FAA) is charged with approval of EFBs for installation and operational use in aircraft. The approval process will be a multi-dimensional effort requiring an understanding of how the device functions and will be used by crews, how the device interacts with other flight deck equipment, and the implications for training and operating procedures. The FAA, both Flight Standards and Aircraft Certification, are in need of guidelines and data to help them evaluate human factors issues related to EFBs. An Advisory Circular on EFBs (AC120-76) was recently issued (July 2002), and there are already a number of applicants who intend to use this document. The AC includes a section on EFB human factors considerations, and it refers the readers to a Volpe EFB human factors document from September 2000 (Version 1) for further information.

The high-level objectives of this project are to:

- Identify EFB human factors considerations
- Provide guidance to the FAA and manufacturers on addressing these issues
- Facilitate development of FAA advisory material and FAA human factors evaluation procedures for EFBs
- Keep the FAA aware of industry EFB development activities

The primary FY02 product is a significantly updated version of the Volpe EFB human factors document titled *Human Factors Consideration in the Design and Evaluation of EFBs.* Material from this document will be incorporated into a revision of the EFB AC, which is expected to be issued in January 2003. A second important product is an industry review of EFB technology, which captures a snapshot of the EFB market at this time. These documents are available to the public at the Volpe EFB website (http://www.volpe.dot.gov/opsad/efb). Both of these products were distributed to the FAA in September 2002 for review.

The Volpe EFB human factors document contains information for FAA evaluators, system designers, manufacturers, and users about the many human factors considerations that are associated with EFBs. Its purposes are to

- Identify and prioritize human factors issues for designers
- Serve as a technical reference for evaluators
- Provide prescriptive guidelines where possible
- Document known design tradeoffs

Guidance is given in the form of *requirements*, *recommendations*, *suggestions*, and *issues* statements. The latest document (Version 2) covers system

considerations and four EFB functions in detail. The functions discussed in Version 2 are electronic documents, electronic checklists, flight performance calculations, and electronic charts. This document is not regulatory. The regulatory application of this information is the responsibility of the appropriate government agencies. Where appropriate, FAA regulations and other industry documents on best design practices are referenced.

Scientific and Technical Objectives: to create a comprehensive reference document that captures all the human factors issues relevant to EFBs. The general topics include usability of hardware, usability of software user interface, integration of hardware and software with existing flight deck systems, and design of training/procedures for EFBs.

Where possible, we provide prioritized, prescriptive guidelines to help system designers and evaluators both. The document contains guidance statements related to (a) the *installation* of the EFB in an aircraft, (b) *training/procedures* for the use of the EFB, and (c) hardware/software aspects of the EFB *equipment*. Where prescriptive guidelines cannot be provided, issues and design tradeoffs are discussed without specifying a "correct" or "best" solution. This document does not focus on best practices. References are pointed out where the reader can explore topics further.

In addition to being a comprehensive and practical reference document, this work is accessible to a diverse readership. The document will be used by FAA regulators (in the field and at Headquarters), as well as EFB customers (i.e., airlines and operators), and EFB vendors who are building these systems. Therefore, we focused our attention at not just the content, but also the usability of the document itself. The format that is used has been widely praised as being easy to use.

Technical Approach: This document was created with input from human factors, industry and FAA experts. It was validated through review of existing and prototype EFB functions and systems. Also, the document was reviewed by industry through a close working relationship with the Air Transport Association's Digital Data Working Group, which is comprised of airlines as well as EFB vendors. We also consulted with industry experts outside of the ATA group, as appropriate. Detailed comments from industry on the Version 1 document were incorporated into Version 2. Guidance from the published EFB AC was also incorporated. Relevant literature was also consulted and cited. For the new electronic charts chapter, a formal issues and requirements analysis was performed.

Results: N/A

Impact/Applications: This project directly supports the regulators at FAA Headquarters who are issuing guidance on the human factors evaluation of EFBs to field offices. The first version of this document (Version 1) was used as both a

reference and source of material for human factors guidance in the current EFB AC. Material from Version 2 is being incorporated into a revision of the EFB AC, which is expected to be issued in January 2003.

Also, this project assists industry EFB designers. By using the Volpe EFB human factors document as a checklist of topics to consider, businesses that are responsible for implementing EFBs can help to ensure that the design of the EFB adequately anticipates and deals with human factors risks that may arise. This benefits not only the safety of EFBs in general, but it also smoothes the manufacturer's path to approval of their EFB.

Technology Transfer: AIR-130 (Aircraft Certification) and AFS-400 (Flight Standards) used Version 1 of the EFB human factors document directly in writing the EFB Advisory Circular (AC 120-76). The AC contains several pages of human factors guidance for the approval and certification of EFBs, much of which originated in the Volpe document on human factors considerations for EFBs. The Volpe document is also cited as a reference document. An updated EFB AC is expected in January 2003. Guidance from the Version 2 EFB document will be incorporated into this updated Advisory Circular.

Journal Articles: None

Books or Chapters: None

Technical Reports: Chandra D. C., Mangold S. J. and Riley, V. (2002). *DRAFT: Human factors considerations in the design and evaluation of electronic flight bags (EFBs) Version 2.* Cambridge, MA: USDOT Volpe Center.

Conference presentations/abstracts: Chandra, Divya C. (2002). Human Factors Evaluation of Electronic Flight Bags. *Proceedings of HCI–Aero 2002*. 23-25 October. Cambridge, MA.

Patents Issued or Pending: None

Honors: None

Related Projects: None

Project Title: *Vertical Navigation/RNP Displays/Symbology*

Primary Investigator: E. Donald Sussman, USDOT Volpe Center, Cambridge, MA

Co-Primary Investigator: Divya Chandra, USDOT Volpe Center, Cambridge, MA (email: chandra@volpe.dot.gov)

FAA Sponsor Organization: AIR-130 (POC: Colleen Donovan)

Sponsor's Requirement Statement: to support development of minimum certification requirements and guidelines for the approval of new moving map displays depicting surface situation awareness, vertical profile navigation information, and required navigation performance.

Research Project's Goal: to categorize the different, commercially available displays helping to understand what makes a display "low-end" or "high-end." Symbology issues are expected to be especially challenging on displays that are low-end.

Continued tracking of government and industry groups that are active in this area will lead to early identification of human factors issues related to emerging symbology. Once the issues are identified, we will begin research on these issues in time to provide input when decisions need to be made.

Best Accomplishment: Industry review of moving map technology. Feedback was provided to the authors of a proposal made by the US to ICAO to improve chart symbol consistency.

Project Summary: to support the FAA in determining what aeronautical chart symbology is appropriate for electronic presentation on moving map displays. The issue is especially complex because moving map technology varies widely, from low-end small hand-held displays for general aviation, to high-end avionics for transport operations.

The second goal of this project is to keep track of government and industry groups that are actively developing chart standards. Standards for moving map display symbology are being addressed in the United States (US) by RTCA Special Committee (SC) 181 Working Group (WG) 4. In parallel with this effort, there is an International Civil Aviation Organization (ICAO) proposal to change their standards document (the Aeronautical Charts Standards and Recommended Practices (SARPS) Annex 4) to include requirements for electronic aeronautical chart displays.

The primary FY02 product is an industry review of moving map technology, which was sent out to participants of RTCA SC181 WG4. Secondarily, feedback was provided to the authors of a proposal made by the US to ICAO to improve chart symbol consistency.

Scientific and Technical Objectives: N/A

Technical Approach: To create the industry review of moving map technology, a web-based search was performed in which we identified all commercially available systems that included a moving map display. The search identified many classes of equipment that supported moving maps, such as panel-mounted systems, electronic flight bags, and hand-held GPS displays. The systems were classified based on their range of capabilities and their physical form factor. For each system, its range of functions, display characteristics, and other pertinent information were gathered and entered into a spreadsheet format.

Results: N/A

Impact/Applications: This project directly supports the regulators at FAA Headquarters who are developing guidance on the human factors issues pertaining to moving map displays through RTCA SC181 WG4.

Technology Transfer: N/A

Journal Articles: None

Books or Chapters: None

Technical Reports: None

Conference presentations/abstracts: None

Patents Issued or Pending: None

Honors: None

Related Projects: None

Project Title: *Human Factors Issues Regarding Airport Surface Information Displays*

Primary Investigator: E. Donald Sussman, USDOT Volpe Center, Cambridge, MA

Co-Primary Investigator: Michelle Yeh, USDOT Volpe Center, Cambridge, MA (email: yeh@volpe.dot.gov)

FAA Sponsor Organization: AIR-130 (POC: Colleen Donovan)

Sponsor's Requirement Statement: to create a comprehensive reference document that captures all the human factors issues relevant to the design and development of surface map applications.

Research Project's Goal: This first version of the surface map document is currently being reviewed by the FAA, and may be presented to industry experts in the future. Additionally, this document will be expanded to include evaluation questions that can be used by FAA evaluators to test for compliance.

This document was used as a source of material for human factors guidance in the development of the RTCA SC-181 draft revision of the *Minimum Operational Performance Standards for the Depiction of Navigational Information on Electronic Maps* (DO-257). This document may also be used to help Aircraft Certification evaluate displays; the industry review provides display examples that show the surface map market at this time and details as to what displays have been certified.

Best Accomplishment: A draft of *Human Factors Considerations in the Design of Surface Map Displays* was submitted to the FAA for review on 30 September 2002.

Project Summary: There is currently a great deal of interest in developing surface map displays to enhance safety and reduce incidents on or near the airport surface. The former Federal Aviation Administration (FAA) Administrator, Jane Garvey, noted that "taxiing on the airport surface is the most hazardous phase of flight … when accident statistics – including those of near misses [sic] – were analyzed, today's airport surface was found to have the greatest potential for major catastrophes" (Gerold, 2001). The National Transportation Safety Board (NTSB) has listed runway incursions as one of its top ten most wanted transportation safety improvements every year since its inception in 1990.

It is expected that surface map displays will enhance safety by providing information that supplements what is available on an electronic chart or paper map with the additional capability of providing real-time information regarding ownship and traffic positions on the airport surface. The surface map is expected to interface to a database that contains positional data describing the location of airport runways, taxiways, non-movement areas, ramp areas, buildings, and hold

lines. Information about other aircraft operating on or near the airport surface and ground vehicles is available through surveillance technologies, such as Automated Dependent Surveillance-Broadcast (ADS-B), which transmits selective information (such as distance and azimuth) from suitably equipped vehicles that may then be received by other suitably equipped vehicles.

The purpose of this work is to create a comprehensive reference document that captures all the human factors issues relevant to the design and development of surface map applications. The FAA is charged with approval of surface map displays for installation and operational use in aircraft. The approval process will require an understanding of how the application will be used by crews and the implications for operational procedures. Aircraft Certification is in need of guidelines and data to help them evaluate human factors issues related to the approval of surface map displays.

The primary FY02 product is a draft report entitled *Human Factors Considerations in the Design of Surface Map Displays*. This document is intended to support Aircraft Certification in their review and evaluation of surface map displays. This document was created with input from experts in the field through discussions with engineers building the displays as well as pilots who used them. Specifications and articles describing individual display features and intended usage for the various surface map prototypes were reviewed.

This document contains an industry review of surface map prototypes and provides examples of surface map displays in development by vendors and research organizations. The opportunity to view these prototypes occurred through invitations to vendors' sites or at public demonstrations. Additionally, this document provides information for FAA evaluators about human factors considerations that may be associated with surface map displays. Guidance presented here is given in the form of *Requirements*, *Recommendations*, and *Design Considerations*. *Requirements*, unless indicated otherwise, are based on research. It is important to note that the use of the term "requirement" here has no regulatory meaning; rather it is a designation based on the expertise of the author and reviewers. *Recommendations* are based on subject matter experts and indicate highly preferred methods or mechanisms. *Design Considerations* identify open questions in the design of surface map displays, and explores design trends that could be considered during design and evaluation, without specifying a "best" solution.

The considerations addressed here include the depiction of display elements on surface maps, the depiction of traffic and issues related to the representation of traffic, the depiction of status indications on surface map displays, the implementation of functionality, general layout and appearance concerns, and operational considerations in the introduction of new equipment. Note that this document is not regulatory. Where appropriate, FAA regulations and other industry documents on best design practices are referenced.

Scientific and Technical Objectives: The purpose of this work is to create a comprehensive reference document that captures all the human factors issues relevant to the design and evaluation of surface map applications. The general topics include the depiction of surface map attributes, traffic, and status indicators; the implementation of functionality; general usability considerations in layout and appearance of surface map displays; and operational considerations in the introduction of surface map displays to the flight deck.

Where appropriate, FAA regulations and other industry documents describing best design practices are referenced. Where possible, prescriptive guidelines are provided to help system designers and evaluators. Additionally, design tradeoffs and issues are described, without specifying a "best" solution. Examples from industry are provided, when available.

This document is intended to be used by FAA evaluators. The industry review provides Aircraft Certification with surface map display examples and details as to what has been certified to facilitate future certification of surface map displays. Additionally, this document lists human factors guidance that the evaluator should consider in certification.

Technical Approach: This document was created with input from experts in the field through discussions with engineers building the displays as well as pilots who used them. Opportunity to view surface map prototypes occurred through invitations to vendor sites or through demonstrations or descriptions at public forums (e.g., technical meetings or Safe Flight 21 demonstrations). Additionally, specifications and articles describing individual display features and intended usage for the various surface map prototypes were reviewed.

Results: N/A

Impact/Applications: This project directly supports the regulators at FAA Headquarters who are developing guidance on the human factors evaluation of surface map displays to field offices. This draft version of this document was used as a source of material for human factors guidance in the current draft *Minimum Operational Performance Standards for the Depiction of Navigational Information on Electronic Maps* (DO-257).

As industry begins the certification process for their surface map displays, FAA evaluators will need to consider many human factors topics, some of which may not be obvious. This human factors document identifies topics which evaluators should consider to deal with human factors issues that may arise.

Technology Transfer: This document is intended to supplement the *Minimum Operational Performance Standards for the Depiction of Navigational Information on Electronic Maps* (DO-257). It is not clear yet in what form the document will be made available to the public. If the FAA chooses to make it publicly available, then this document will benefit surface map vendors who are building these

displays by identifying usability issues early on in the product development process.

Journal Articles: None

Books or Chapters: None

Technical Reports: Yeh, M. (2002). DRAFT: Human factors considerations in the design of surface map displays. Cambridge, MA: USDOT Volpe Center.

Conference presentations/abstracts: None

Patents Issued or Pending: None

Honors: None

Related Projects: None

Project Title: *Human Factors Guidelines for Certification of Head-Up Displays*

Primary Investigator: E. Donald Sussman, USDOT Volpe Center, Cambridge, MA

Co-Primary Investigator: Michael Zuschlag, USDOT Volpe Center, Cambridge, MA, (email: zuschlag@volpe.dot.gov)

FAA Sponsor Organization: ANM (POC: Dale Dunford)

Sponsor's Requirement Statement: to help certification authorities identify and evaluate design features that adversely affect pilot performance, awareness of flight hazards, and potential for human error.

Research Project's Goal: This is the first time cate that Hidden Markov Models (HMMs) have been used as a measurement tool for evaluating flight performance. Once established and validated in this HUD application, HMMs may be used in research wherever proper allocation of visual attention is a relevant measure. In flight deck human factors this includes the evaluation of the effectiveness of procedures and training, as well as other electronic displays (e.g., synthetic vision).

The clutter measurement tool under development is being designed to generalize to the evaluation of any individual or a set of electronic displays. When the tool is completed, other displays can be evaluated by swapping in a different knowledge base containing the identity and importance of the information presented. The tool is the only known clutter measuring technique based on the neurophysiology of human visual perception. Currently the only means of objectively evaluating clutter in a display is by crude pixel count or by a time-consuming experiment on a sample of users.

Best Accomplishment: Completed installation, testing, and debugging of eye tracking hardware and software that will provide most of the data for the HMM analysis. Unlike earlier attempts, this eye tracking apparatus limits encumbrance of the pilot to that comparable to a typical aviation headset.

Project Summary: An increasing number of airlines are installing head up displays (HUDs) in their transports primarily to allow takeoffs and landings in very low visibility. Manufacturers are meeting this increased demand for HUDs by marketing new models with various innovative features. These HUDs present human factors issues with regard to the accessibility to the information displayed, where the HUD elements should be sufficiently conspicuous so that critical information is apparent but are not so prominent as to interfere with each other or the out the window (OTW) view. FAA Certification needs guidelines for evaluating HUD designs in this respect. This project seeks to provide these guidelines by two methods:

- Experimental evaluation of HUD design features in a human-in-the-loop flight simulator, using novel high-sensitivity measures of performance as well as traditional measures.
- Development and validation of a computational clutter evaluation tool that will allow certifiers to predict and analyze clutter effects without performing flight tests.

Technical difficulties associated with the eye tracker apparatus have been resolved, and preliminary plans for the first full-blown experiment are ready. Human-in-the-loop simulator runs using the eye tracker indicate that HMMs are a promising tool for measuring pilot attention while using a HUD. The measuring of attention will allow a more sensitive evaluation of HUD design features than provided by traditional measures such as flight technical error or reaction time to events. A literature review of computational models of human perception is completed and work may begin on a method to measure HUD clutter.

Scientific and Technical Objectives: The first experiment has the following objectives:

- Validate the use of HMMs as a measurement of attention allocation by replicating a study on HUD symbology. A correlation between the results in the HMM and in traditional performance measures will establish the concurrent validity of the HMM.
- Determine the importance of gradation marks on primary flight instruments as used in HUDs. Such gradation marks are recommended by the FAA's AC 25-11, but prior HUD research implies that these marks are unnecessary. However, this prior research did not have HMMs, which may indicate important benefits for gradation marks.

Later experiments will evaluate other design features of HUDs that the FAA has identified as requiring research for certification guidance. These include the display of performance targets and limits and the effects of centrality of the symbology. Later experiments will also be used to validate the clutter measurement tool, which FAA certifiers may use to evaluate HUD designs yet to be conceived.

Technical Approach: The first experiment will present the pilots with three alternative formats of air speed and altitude indications in the HUD: digital only, counter-point with gradation marks, and counter-pointer without gradation marks. This is a replication of an earlier experiment in HUDs that found the counter-pointer format to be superior to digital only, while no effect was found for gradation marks. This experiment differs from the earlier study in two significant ways:

- The pilot must perform more complicated maneuvers, including localizer and glide slope capture and go-around.
- HMMs will be used to evaluate the effects of the different formats on pilot attention allocation.

It is expected that this experiment, like its predecessor will find the counter-pointer formats to be superior to the digital format. This superiority should be manifested in both measurements of flight technical error and attention allocation. Parallel results in flight technical error and attention allocation as measured with the HMMs serve to validate the use of HMMs as a tool to detect operationally significant differences in pilot performance.

It is also anticipated that the HMM will detect superior performance for the counter-pointer format with gradations, while fight technical error differences may be weak or non-significant. In addition to providing evidence for the need for gradation marks in HUD instruments, where earlier such evidence was lacking, this finding will establish that HMMs are a more sensitive measure of performance than flight technical error.

Later experiments will follow the paradigm established by the first, using HMMs among other measures to evaluate HUD design alternatives, only now turning attention to design issues that have not been directly addressed by the literature (e.g., the display of performance targets and limits, effects of centrality of the symbology). Furthermore, these studies will also be used to validate the clutter measurement tool, where design alternatives indicated to have greater cluttering (e.g., those with greater centrality of symbology) are predicted to cause poorer pilot performance as measured by attention allocation, event reactions times, and flight technical error.

Results: N/A

Impact/Applications: The FAA sponsor has identified the presence or absence of gradation marks as a design issue for which guidelines are required. Gradation marks are generally recommended for electronic displays (AC 25-11) but some research suggests they may be unnecessary clutter for a HUD. FAA certifiers have been confronted with HUD designs that lack gradation marks, and this has lead to difficulties in achieving effective evaluation for certification. Other issues identified by the FAA also require objective data to replace subjective impressions in order for the certification of HUDs to be valid and consistent.

With the availability of a clutter measurement tool based on human perception, certifiers will be able to evaluate rapidly and cheaply the acceptability of the clutter of a HUD for any HUD symbology format or arrangement. Objective performance predictions will be available without conducting experimental tests for clutter effects for every design conceived by a manufacturer. The tool will also be made available to manufacturers who may use it to design HUDs with a better balance of clutter, resulting in safer displays.

Technology Transfer: The results of specific studies will be summarized and disseminated to FAA certifiers concerned with certifying HUDs. The summary is expected to describe specific procedures and criteria for evaluating HUDs.

The computational clutter metric will be encapsulated into a computer application distributed on CD-ROM. Manufacturers or FAA certifiers input details of a HUD design into the application probably via a Microsoft Access form. Based on this input, the application simulates human perception of the HUD across various conditions and provides an overall clutter score and diagnostic information about the display. To guide certification, FAA certifiers compare the overall score to a criterion score, which is based on the simulated performance of currently accepted and deployed HUDs.

Journal Articles: None

Books or Chapters: None

Technical Reports: None

Conference presentations/abstracts: Zuschlag, M. K. (2001). Issues and Research Needs Concerning the Use of Head-Up Displays in Air Transports. *Twentieth Digital Avionics Systems Conference Proceedings*. Daytona Beach, FL

Patents Issued or Pending: None

Honors: None

Related Projects: None

Project Title: *Certification Issues of Situation Awareness and Navigation*

Primary Investigator: E. Donald Sussman, USDOT Volpe Center, Cambridge, MA

Co-Primary Investigator: Michael Zuschlag, USDOT Volpe Center, Cambridge, MA, (email: zuschlag@volpe.dot.gov)

FAA Sponsor Organization: AIR-130 (POC: Colleen Donovan)

Sponsor's Requirement Statement: to support development of minimum certification requirements and guidelines for the approval of new moving map displays depicting surface situation awareness, vertical profile navigation information, and required navigation performance.

Research Project's Goal: to serve as guides for future scientific research. In particular, issues associated with profile situation awareness displays will require research in order for such displays to realize fully their potential for improving safety. The content of such research is currently under discussion with the FAA sponsor.

Best Accomplishment: The draft MOPS for RNP map displays was completed in September of 2002, with elapsed time from conception to completion of eight months.

Project Summary: The FAA needs minimum certification requirements, guidelines, and documentation of issues for two emerging map display technologies:

- Profile situation awareness displays, which graphically display the vertical and longitudinal dimensions of the flight environment.
- Required Navigation Performance (RNP) map displays, which are designed to provide navigation information in an RNP environment.

This project provides such information to the FAA sponsor through industry and literature reviews, participation in Radio Technical Commission for Aeronautics (RTCA) subcommittee meetings, and the production of RTCA Minimum Operational Performance Standards (MOPS) and issues papers. Standards written through this process are to be directly referenced in Technical Standard Orders (TSOs) for these display technologies.

A draft issues paper for profile situation awareness displays is under review by the FAA sponsor. Additional information has been collected concerning two of the issues documented in that paper. Substantial contributions were made to the MOPS for profile situation awareness displays, with these standards now approaching their final form.

The issues related to RNP map displays have been documented. With the writing of an introduction and other ancillary information, a completed issues

paper can be submitted to the FAA sponsor. The MOPS for RNP map displays has been drafted and is currently under review by the appropriate RTCA working groups.

Scientific and Technical Objectives: to provide the FAA with standards for the performance of the human-machine interface of electronic maps, specifically RNP maps and profile situation awareness displays.

The project also seeks to document the human factors design issues regarding electronic maps of these types in order for the FAA to prioritize and select future research needs that will best address certification questions.

Technical Approach: Standards and issues are compiled through conducting and analyzing industry and literature reviews. In part, these were performed through interviews with industry and government avionics experts in the course of participating in RTCA working groups charged with developing standards for navigation avionics.

Results: N/A

Impact/Applications: Standards documents written as a product of this project are to be referenced by FAA TSOs, providing FAA certifiers with the means to rapidly, consistently, and effectively certify electronic maps intended to have an RNP or profile display capability. Issues identified by this project serve to guide FAA research requests to areas where knowledge is most needed for the purpose of ensuring safe avionics design.

Technology Transfer: None

Journal Articles: None

Books or Chapters: None

Technical Reports: None

Conference presentations/abstracts: None

Patents Issued or Pending: None

Honors: None

Related Projects: Flight Deck Human Factors - Certification Issues of Situation Awareness and Navigation Displays: Airport Surface Information

Appendix II

Human Factors Flight Technologies

Research Requirements

Research requirements exist in the AAR-100 interactive management database that allows program managers to track research requirements for each Federal Aviation Administration sponsor.

Requirement ID: 623

Sponsor Organization: ANM POC: K. Abbott & Loran Haworth

Requirement Title: Certification Job Aid

Funded Requirement:

- FY02: Yes
- FY03: Yes
- FY04: Yes
- FY05: Yes

Requirement Statement: Human factors research is needed to provide a capability for certification personnel to evaluate flight deck designs for susceptibility to design-induced flight crew errors and the consequences of those errors as part of the type certification process.

Background: Research task: Develop human factors job aid for use by certification personnel. FY 01 tasks: - add additional Part 25 guidance such as TSOs, MOPS and other industry standards - identify human factors issues related to the certification of flight deck controls - add functionality such as search, notes, issue paper template, update of FARs Ranking Criteria: Internal drivers: Essential. On the AIR Business Plan for FY01 and may be on the AIR plan as well. Potential to reduce accidents: Important. The Job Aid supports flight deck design certification. Flight decks designed and certified without undue potential for flight crew error is the first line of defense in accident prevention. External drivers: Important. Supports ARAC HF HWG activities. New technology: Important. The Job Aid will provide revelent human factors information which will support the certification of new tecknogies. Note: Directly supports Change Area II (Human Factors Integration) of Certification Process Study implementation.

Output: Support tools for certification personnel to identify HF issues.

Regulatory Link: Supports integration of HF references with Part 25 regulations, advisory circulars, and TSO on displays.

Requirement ID: 631

Sponsor Organization: AFS POC: Archie Dillard

Requirement Title: Cockpit Communications

Funded Requirement:

- FY02:
- FY03:
- FY04:
- FY05:

Requirement Statement: Human factors research is required to provide guidance and regulatory material regarding human factors communications issues related to the introduction of new technologies and operational procedures into the modern cockpit.

Background: Conduct pragmatic human factors studies on communications issues related to the introduction of new technologies and operational procedures into the modern cockpit. The proper implementation of these new initiatives is critical to meeting the near- and long-term NAS safety goals. The automation inherent in many of these new systems and procedures represents a dramatic departure from tradition, in many areas. Flight crews will be bombarded with visual and aural data from numerous sources, while increased traffic and cockpit workload increases associated with the free flight initiative will make it increasingly difficult to efficiently manage the advanced cockpit. Tasks to be included under this project will include: - The expanded use of aural information as an adjunct to cockpit displays. - Prioritization of different modes of communication under various operational modes in the advanced cockpit, i.e. visual over voice over, etc. - Alerting and emergency annunciation. - Feasibility of the use of voice recognition equipment in the cockpit. - Replacement of traditionally displayed data with synthetic voice. - Evaluation of 'mode limiting' of communications under various operational modes and phases of flight. - Under what conditions would the preferred mode of communications be graphically data linked or data file displayed, voice alerted, or textual messages. - Reducing crew/crew and crew/ground voice communications without impacting operational safety and efficiency. This work will be a collaborative effort with AFS, CAMI, FAATC and outside participation of academia and industry.

Output:

Regulatory Link:

Requirement ID: 622

Sponsor Organization: AIR POC: Colleen Donovan

Requirement Title: Data Link

Funded Requirement:

- FY02:
- FY03:
- FY04:
- FY05:

Requirement Statement: Human factors research is needed to provide necessary certification and regulatory guidance and mitigate risks associated with the implementation and integration of CPDLC on the flight deck.

Background: Continuation of on-going work at NASA (Sandy Lozito) FY01 work requested: Modification & extension of current tasks in existing statement of work (see Tom McCloy for a copy of this). Task 0: (Nadine Sarters old task)- FMS Integration (use of CPDLC in modern flight deck- examine pilots ability to integrate, sit. awareness. Examine risks with potential Build 2 implementations & Nexcom. What are the HF issues we need requirements to guard against? Task 1: Support data link AND-370 HF demo from the research side- integrate NASA simulator into trials, run test subjects & collect data to support demo (before and during demo). Task 2: Test & modify data link usability pilot evalaution form (like a fleshed-out ASRS usability assessment form) . Collect data using assessment form on FANS using subject/pilots. Crunch data on usability. Determine if assessment form caught the known "big HF issues" with FANS, modify form as necessary. Produce report and final form to be used in CPDLC American Airlines Human Factors Assessment & other follow-on airlines. Task 3: Demo plan research team. Support folding lessons learned into new RTCA SC-194 special committee(s). Assist request for human factors input into safety assessment work being done by RTCA SC-189 and RTCA SC-194. Support HF CPDLC tasks identified in CPDLC Human Factors Roadmap document (January, 1999). Task 4: CAPSTONE plan review. Review program and research plans on the Capstone program to provide input from an experimental, research, data collection perspective- paying particular attention to what can and should be done on data link in the Capstone program. Priority: Internal: 2 (useful) Potential to reduce: 2 (useful) External Drivers: 3 (important) Supports resolution of safety issues required to develop policy as identified in RTCA (see Free Flight Select Committe- HF CPDLC Roadmap activity) New Technology: 3 (important)- allows FAA/AVR to respond in a timely fashion- NT.

Output: Note: this item should not be considered for funding in FY 03 or after. AIR request ends in FY 02

Regulatory Link:

Requirement ID: 639

Sponsor Organization: AIR POC: Colleen Donovan

Requirement Title: Electronic Flight Bag

Funded Requirement:

- FY02: Yes
- FY03: Yes
- FY04:
- FY05:

Requirement Statement: Human factors research is needed to provide certification (AIR), operational approval, and training (AFS) guidance, including input to AC's, as well as to mitigate risks associated with the implementation and integration of electronic flight bags on the flight deck. One goal is to develop and test methodology for evaluating EFB usability for Certification and Flight Standards Work should be in three sub-task areas: Task 1: Finish/update the "Human Factors Considerations for the Design and Evaluation of Electronic Flight Bags, Version 2" document Task 2: Develop a WEB/HTML/Hypertext version to facilitate ease of document use Task 3: Develop EFB Evaluation methods and tools for AIR & AFS to use during certification and operational approval, to ensure HF/pilot interface issues are identified, documented, and resolved. Note: High Priority- this work was flagged by AVR-1 as critical.

Background: EFBs typically consist of a screen and controls in a self-contained unit that is relatively small weighing only a few pounds. They can be hand-held portable devices or mounted in the flight deck. They may be passive display or interactive, and can stand alone or connect to on-board and/or ground systems. Aircraft certification specialists are currently being asked to review and approve new electronic flight bags including complex integrated electronic checklists with functionality well beyond what has been approved in the past. Serious potential consequences may arise if these specialists approve something that should not be approved, as some of these systems have cursor control devices controling aircraft systems (engines etc.). The FAA is working on an advisory circular which is intended to contain guidance on the identification and resolution of human factors/pilot interface issues with these types of systems in order to determine what is acceptable and what is not. This material needs to be data driven and research is need to identify potential issues and resolutions. EFB Includes work on evaluating systems (e.g., Northstar & Avionitek)to gather data. Explore developing a generic interface philosophy document to help standardize look & feel of all applications (as Microsoft does with the design guide/philosophy document). Requires working with appropriate ATA and SAE committees, potential airline users, and avionics vendors. Joint AFS/AIR need, since an EFB may require both operational and airworthiness approval(could be plug in laptop or built in system hard-wired to the airplane). Do a usability assessment of

currently fielded and potential EFB systems in order to evaluate the issues with these systems. This should include an evaluation of the prototype systems being developed by United Airlines and others. All features functions of these units should be evaluated from a human factors perspective and initial data should be collected from subjects to assess the potential errors with these systems and their consequences. Results should be fed into revisions to the document and associated FAA AC.

Output: Electronic Flight Bag- FY 03. Task 1 output: Update to Volpe Document (currently referenced in FAA AC 120-76) “Human Factors Considerations for the Design and Evaluation of Electronic Flight Bags, Version 2”. Update will include revisions to ensure: 1) document is consistent with newly updated EFB AC, 2)comments from technical sponsors are addressed, 3) document structure optimized for ease of end reader/user- based on input from EFB Northstar evaluation, and 4) updated industry review appendix. Update will also include a new quick reference evaluation checklist appendix. Task 2 output: WEB/HTML/hyperlink version of the “Human Factors Considerations for the Design and Evaluation of Electronic Flight Bags, Version 2” document to facilitate ease of use by three target audiences (pull up chapter/issues on: equipment, training/procedures, or instalation issues without having to go through the full 150 pages. Task 3: EFB Evaluation Methods and Tools for AIR & AFS. Product 1 for AIR: Quick reference checklist developed for the version 2.0 document should be tested and refined. Comprehensive EFB human factors/pilot interface issues list will be developed, to serve as the basis for Certification Issues Papers. Thus ensuring the issues on certification projects are appropriately addressed and documented. Product 2 is a quick reference equaluation list for AFS (including the Airplane Evaluation Group- AEG) evaluations of EFBs.

Regulatory Link: Advisory Circular 120-76

Requirement ID: 901

Sponsor Organization: AIR POC: Bill Kaliardos

Requirement Title: Electronic Maps: Panning, zooming, rotating, and decluttering

Funded Requirement:

- FY02:
- FY03:
- FY04:
- FY05:

Requirement Statement: Research is needed to understand the safety implications of the four basic display manipulation functions: panning, zooming, rotating, and decluttering. One or more of these display functions are critical to nearly all electronic depictions of the environment--loosely defined here as an electronic "map." This includes standard aeronautical maps and charts, as well as depictions of traffic, weather, and terrain.

Background: The design and certification of display manipulation functions tends to be ad hoc, despite that these same functions are ubiquitous on electronic depictions of the environment. The electronic depiction of information--that was traditionally obtained via paper or other physical mean--offers obvious benefits, but also introduces potential human factors safety problems when (literally) navigating this information on a display. Unlike paper maps, for example, in which the manipulation states are intuitive and immediate (e.g., it's quick and easy turn a map 45 degrees, and hard to lose track that it is being held in that position), electronic maps may be slower, discontinuous, and may not effectively communicate the controlled state. The result can be excessive workload or errors in understanding display information. *The four display manipulation functions--panning, zooming, rotating, and decluttering--are considered together not only because they are common requirements of displays, but because their states have common control issues to consider, such as:*

1. Active versus automated manipulation (e.g., moving map or automated decluttering)

2. Returning to default settings (e.g., standard zoom), especially when the default is not static (e.g., changes with flight phase)

3. Intuitive and standardized controls for manipulation

4. Feedback of current manipulation states (e.g., current zoom level) 5. Workload associated with display manipulation

6. Controllability (speed, latency, continuity, overshoot and stability)

In order to have the widest impact, this research should not be application-specific. However, it can use currently developed technologies and applications in order to generalize appropriately to other aircraft displays.

Output:
1. Review of current research literature

2. Safety and performance assessment of display manipulation functions currently used

3. Human factors guidance to assist designers and certification policy developers

Regulatory Link: Electronic Flight Bag AC, Moving Map TSO

Requirement ID: 641

Sponsor Organization: AIR POC: Kathy Abbott

Requirement Title: Error Management

Funded Requirement:

- FY02: Yes
- FY03: Yes
- FY04:
- FY05:

Requirement Statement: Human factors research is required to provide guidance and regulatory material regarding the need for better support of error management to mitigate the consequences of erroneous actions and assessments.

Background: This work is a continuation of work funded in FY 00 investigating the need for better support of error management to mitigate the consequences of erroneous actions and assessments (being done by Dr. Nadine B. Sarter). There are two major approaches to the problem: error prevention and error management. The prevention of errors through improved training and design has been the focus of much research and development in the past. It is widely acknowledged, however, that it is impossible to eliminate, or prevent, completely the occurrence of errors. Therefore, it will be critical to find ways to mitigate the consequences of errors that will continue to occur. To date, however, little is known about effective support for error management, which involves the following three steps: error detection, error explanation, and error correction or recovery. This research project will focus on error detection and error recovery. One of its goals is to identify, and examine the impact of, factors that contribute to successful and poor error detection performance. We will also analyze different strategies for error correction and recovery (e.g., backward, forward, or compensatory strategies) and determine their effectiveness in different task contexts. Based on this knowledge, the longer-term objective of this effort is to develop concepts for off-line support (in the form of training) and on-line support (through design) of error management, especially in the context of modern aviation technologies and operations. The methodological approach will involve both observations of pilot and crew behavior - a technique that has been used before - and more controlled studies of error management of which very few have been conducted in this field of research. Some of the questions that will What is the relationship between different error? be investigated are types/errors at different performance levels and error detection cues and What are the reference mechanisms against which actions or their? processes? What are the main factors that lead to detection? consequences are checked? How can we support operators in detecting errors of omission and? failure? errors at the knowledge-based level, which tend to be more difficult to notice? How does self-

detection differ from detection by other operators, and how can? How do error? these differences be exploited through training and procedures? detection and correction performance and strategies change as operators gain What determines the choice of an error? more experience in their domain? How well do current automation technologies support the? recovery strategy? detection of, and recovery from, erroneous actions and assessments? Research Plan. During the first year of this project, the following activities will be Review of existing knowledge and important research questions in? performed: the field of error management The findings from studies, the general applicability of their results, and the questions that remain unanswered or that were raised by this research, will be discussed and summarized in a technical report. This report will be shared with the FAA and will, to some extent, inform Observations of pilot training at a major? our subsequent research activities. carrier. In parallel with the above activity, we plan to establish a collaboration with a major airline. Our first step in this collaborative effort will be observations of training sessions and the participation in debriefing sessions to examine a) what errors are likely to be detected/missed by the crew, b) which crewmember tends to detect the error, c) what cues/mechanisms help the person detect the problem, d) how the two crewmembers communicate about observed errors, e) what strategies they use when trying to recover from the error, and f) how successful their different strategies are. We will sample different types of modern technology aircraft to examine how differences in feedback design and automation behavior may affect error management. In particular, we hope to be able to examine error management in the context of modern technologies and operations such as FANS and RNAV operations. We will also sample pilots at different levels of experience to investigate the impact of experience and crew position on error management behavior and performance. The findings from these training observations will be summarized in a second technical report to the FAA. Together with the findings from our research review, the results of these observations will guide our next steps in this research during the second and Pilot reviews of,? third year of the project. One likely next activity will be and pilot participation in, staged simulator sessions involving various types of errors In order to go beyond naturalistic observations and instead examine specific hypotheses about error management behavior and performance, we will design a set of scenarios that involve multiple opportunities for different types of errors. The same scenarios will also be flown by one of the confederate pilots together with a naïve study participant. These different setups will help us learn more about the differences between self-detection and error detection by another operator. The above scenarios will also be staged in different contexts (e.g., high versus low time pressure), with pilots at different levels of experience, and on different flight decks to examine possible differences in error management behavior. During the second and third year of the project, we plan to address issues such as a) the detection of erroneous assumptions and actions on the part of the automation by the flight crew, b) the impact of different feedback designs on error detection performance, and c) the assessment of the most adequate error recovery strategies for different types of errors and task contexts. Our

research will be conducted in the context of flight simulations at varying levels of fidelity. The findings from these research activities will enable us to collaborate with the airline on the development of new approaches to error training, especially with respect to the detection of and recovery from omission errors and errors at the rule-and knowledge-based level. Summary. Since it is impossible to eliminate errors completely, we need to find more effective ways of mitigating their consequences through training, design, and procedures. To this end, we will examine the processes and factors involved in successful and poor error management. In particular, we will investigate error detection and recovery strategies and performance for different types of errors and task contexts, different levels of pilot experience, and different flight deck designs. By conducting controlled studies of error management, our research will go beyond most earlier research in this area, which relied, for the most part, on naturalistic observations of flight crew behavior during actual line operations. We hope to contribute to the continued safety of flight operations in the future through the development of more effective approaches to error management training and through the identification of problematic system and interface designs that can hinder error detection and recovery.

Output: Guidelines and methods for the identification of problematic system and interface designs that can hinder error prevention, detection, and recovery

Regulatory Link: Supports regulatory material being developed by Human Factors Harmonization Working Group for HF in FAR/JAR 25. Also applies to regulatory material for training/qualification and crew procedure design.

Requirement ID: 898

Sponsor Organization: AIR POC: Bill Kaliardos

Requirement Title: Evaluation of Situation Awareness¡¨ as an intended Function

Funded Requirement:

- FY02:
- FY03:
- FY04:
- FY05:

Requirement Statement: Human factors research is needed to provide guidance for the certification of devices whose function is claimed to be for "situation awareness." It is hypothesized that some of these devices are compelling to use beyond situation awareness, and can adversely affect flight deck decision making. Research will develop a database of such evidence, and propose explanations based on an analysis of flight deck decision-making. Based on this understanding, a resolution for the certification process will be proposed.

Background: Many applicants develop flight deck information tools that are to be used "for situation awareness only." Examples are compelling displays such as: „h moving charts with own-ship „h enhanced/synthetic vision „h highway-in-the-sky „h perspective terrain display „h traffic information display „h weather display From a certification standpoint, situation awareness (SA) has provided applicants with a means to maintain a purposely vague description of intended function, resulting in a less-costly certification path. SA-based arguments assert that the pilots don't really do anything significant with the information. In contrast, we assert that: 1. Pilots in fact can significantly alter their decision-making based on SA devices 2. The altered decisions are sometimes unsafe 3. Cognitive workload is sometimes increased when integrating a device's information with the other flight deck information (e.g., when altitudes don't agree). To support these hypotheses, research will perform an inventory of previous cases in which "situation awareness" was the intended function. These cases will be analyzed to understand the issues raised during the certification process, and to understand the specific ways in which flight deck decisions might be altered. Where possible, experimental data from flights will also be used. We expect to not only find data that clearly supports our hypotheses, but also expect to explain pilot behavior. This, in turn, can provide certification specialists with the necessary grounds for preventing the approval of unsafe situation awareness tools.

Output: 1. Inventory of previous situation awareness functions 2. Analytical framework for predicting problems in situation awareness functions 3. Guidance material for certification specialists

Regulatory Link: Regulation 25.1301 and equivalents (23.1301, 27.1301, 29.1301). May propose cross-FAR AC or policy memo to facilitate field reviews of SA displays

Requirement ID: 612

Sponsor Organization: ANM POC:

Requirement Title: Flight Deck Alerting

Funded Requirement:
- FY02:
- FY03:
- FY04:
- FY05:

Requirement Statement: Human factors research is needed to support the updating of FAR 25.1322 addressing flight crew alerting.

Background: Conduct a literature review to identify key research projects conducted since the FAA funded study "Aircraft Alerting Systems Standardization Study" published in 1981. Review would include US and European studies. This activity support the ARAC Avionics Harmonization Working Group. Ranking: Internal drivers: Important. Updating 25.1322 is one of the FAA Team Report recommendations. This research activity directly supports the ARAC HWG to update the rule. Potential to reduce accidents: Important. Several of the JSAT recommendations have been forwarded to the JSIT level and are part of implementation packages. External drivers: Important. Directly supports ARAC tasking. New technology impact: Essential. This research directly supports the development of advisory material for emerging technologies such as TAWS and Turbulence information.

Output:

Regulatory Link:

Requirement ID: 896

Sponsor Organization: AIR POC: Glen Gallaway

Requirement Title: Graphic Presentation of Human Factors Information in ACs, Guidelines, and Other Documents

Funded Requirement:

- FY02:
- FY03:
- FY04:
- FY05:

Requirement Statement: Develop guidelines for use of graphics and formatting to improve the readability/usability of our FAA documents (ACs, TSOs, etc.) and FAA reports. Note: This is recommended as a small CSERIAC search ($5 K or less).

Background: A great deal of human factors information deals with tangible (and visual interfaces between people and an aircraft (displays, controls, environment, presented information, etc.). Many FAA documents present this human factors information in a text only format. This text presentation is an attempt to use words to describe a visual image. Creating an effective, accurate text translation of an issue is time consuming, difficult, and error prone. To find issues in text it is necessary to read the full text and separate it from the support verbiage. Then one must translate the text back into a visual image for processing. This processing is supposed to lead to understanding of the issue, but this second translation can potentially introduce a second misinterpretation of the issue. Human factors handbooks, training material, standards documents, and other media have effectively employed graphics (visual images) to quickly and accurately convey concepts and description information. This research will explore how the FAA can effectively employ graphic presentation of human factor information to improve the use of our documentation.

Output: Report to include: 1) Identify a sample of approximately 100 human factors issues that are described in text in FAA documents.

2) Develop drawings, graphics, tables, pictures, or other media that can visually depict each issue.

3) Develop text that support, clarify, and explain each visual depiction.

4) Test the performance (accuracy, speed, and effectiveness) of a FAA document or section of a document that employs graphics and text Vs the same document that only uses text. Evaluation must be performed with intended document users.

5) Create a graphics library architecture that would support identifying and applying issue graphics/text. Implement a prototype library for the graphics issues described above.

6) Present a plan/schedule (time, not dates)/cost for expanding this process to the majority of human factors issues dealt with in the FAA. Include methods of adding new issues.

7) Define library ongoing maintenance procedures and estimates of resources need

Regulatory Link: Update several AC's and TSO's, as well as form input to the Plain English guidelines which document recommendations for drafting new FAA material

Requirement ID: 897

Sponsor Organization: AIR POC: Glen Gallaway

Requirement Title: HF Information Support Center ¡V Internet Web-Site Delivery System Architecture & Design Requirements

Funded Requirement:

- FY02:
- FY03:
- FY04:
- FY05:

Requirement Statement: Define the architecture and design requirements for an internet web-site that will help uses search for, obtain and structure human factors information for various certification and flight standards objectives. Using the design requirements develop a working prototype web-site that will demo the delivery of information. User test the site for human factors design and performance. „h Identify user¡¦s (FAA personnel, vendors, flight crew) needs for human factors information (possibly use product of other research projects). „h Determine how the information must be formatted and presented to be useable by users (possibly use product of other research projects). „h Identify links/descriptions to related information. „h Identify the operational information that FAA Human Factors personnel need to exchange. Define the structure / layout a secured portion of the website that can be used to communication this information. Make this portion of the web-site interactive and maintainable by the owners of the information. „h Include a process for recording certification actions taken relative to equipment and processes. This information should be auto indexed. „h Implement a prototype database driven web-site. Make the web-site maintainable by professional human factors personal with little computer skills required. „h Human factor the website. Use human factors experts, graphic artists, and database experts as needed to ensure a useable, user-friendly, and effective prototype design. User supported design and testing is required.

Background: A great deal of human factors research, design, development, and information is created / obtained for use in the FAA. Often it only used by a small group because it¡¦s existence is not widely known. This information could potentially have much broader value if it was made available to all whom need it for human factors work. A good approach for broadly delivering human factors information is via an internet web-site. An effective web-site must be based on presenting the information needed by the users in a form they can readily use. This project will match user information needs with good information delivery practices

Output: „h Web based human factors information delivery architecture that matches the needs of the various users with the information available. „h A

prototype web-site that demonstrates effective delivery of information. „h Web-site human interface that is human factored (and user tested). „h A prototype FAA human factors communications exchange site section (activities, bios, schedules, projects) maintainable by the information owners. „h A prototype site section that is a human factors educational resource (teaches HF) for internal and external personnel. This should be very limited (only show intent). „h Provide a plan for transitioning the prototype into an operational web-site. Describe maintenance requirements, cost of development, time needs, and personnel resources.

Regulatory Link:

Requirement ID: 892

Sponsor Organization: AIR POC: Glen Gallaway

Requirement Title: HF Knowledge Central – Framework for Finding/ Applying HF Knowledge in Certification Process

Funded Requirement:

- FY02:
- FY03:
- FY04:
- FY05:

Requirement Statement: 1. Determine the most effective way for FAA Flight Standards and Certification Personnel to identify human factors issues in their work. Field evaluation of real work required. 2. Determine the most effective way for FAA Flight Standards and Certification Personnel to obtain human factors information that meets their needs identified in # 1. Field evaluation of real work required. 3. Determine the most effective way for FAA Flight Standards and Certification Personnel to apply human factors information that meets their needs identified in # 1. Field evaluation of real work required. 4. Identify the most promising 3-5 methods/tools that support # 1, 2, and 3 above. 5. Develop prototype systems using the top 2 methods/tools identified in # 4. Use the sample cases provided for a TC approval issue and TSO approval issue. Test in the field to determine before and after performance. 6. Propose an initial implementation of the most promising method/tool system. Note: This work must be able to deal with all types of human factors issues (examples below) although they all do not have to be dealt with in the prototype demo. · Software · Cabin Cockpit Controls/Displays Interfaces · Flight Cabin Interfaces · Ground Support Interfaces · Other Aircraft Interfaces · Crew issues · Controller Issues · Communications · Maintenance.

Background: The process of identifying the human factors issues in the certification process is difficult because of the complexity of the interaction between humans, equipment, procedures, and the environment. The more knowledge and experience that the participants in certification process have the more effective the process is. Unfortunately human factors knowledgeable people are not available for all certification project. In this case the people participating would benefit greatly for a support tool that helps quantify the project in terms of the human factors issues and provides the data and knowledge that can effectively equate and certify equipment and procedures. This project is to explore employing current off the shelf (COTS) solutions that will simplify and improve the human factors aspects of the certification process.

Output: .Report on the 3-5 most promising support methods/tools. 2. Prototype of two most promising approaches to improve obtaining and delivery of human

factors information. These tested against current certification process. 3. Plan for initial implementation of the most promising method/tool system.

Regulatory Link:

Requirement ID: 808

Sponsor Organization: AIR POC: Colleen Donovan

Requirement Title: Highway in the Sky/Synthetic Vision

Funded Requirement:

- FY02:
- FY03:
- FY04:
- FY05:

Requirement Statement: Research is needed to invesigate human factors/pilot interface issues with proposed highway in the sky and synthetic vision systems proposed by Universal Avionics, NASA, Rockwell Collins, and others in order to assist the aircraft certification specialist identify and resolve (determine acceptable means of complaice) with these issues.

Background: Aircraft certification specialists are currently being asked to review and approve new highway in the sky/synthetic vision systems, which may be "for situation awareness only" but be placed in a compelling area of view, such as the pilots primary field of view. This includes the Universal avionics system, the NASA system, and a Rockwell Collins system with functionality well beyond what has been approved in the past. Serious potential consequences may arise if the aircraft specialists approve something that should not be approved. To date the FAA has no published guidance on human factors issues with these types of systems in order to determine what is acceptable and what is not. This material needs to be data driven and research is need to identify potential issues and resolutions.

Output: 1) Research report documenting potential human factors/pilot interface issues. 2) Issues list- to be used for generating aircraft certifcation issue papers 3) Industry Product Review - including descriptions of what is being developed and presented by industry in this area

Regulatory Link: AC 25-11 and 23.1311-1A (both are about to be updated, and should include appropriate guidance material for synthetic vision systems)

Requirement ID: 633

Sponsor Organization: ANM POC: Dale Dunford

Requirement Title: HUD certification

Funded Requirement:

- FY02: Yes
- FY03: Yes
- FY04:
- FY05:

Requirement Statement: Human factors guidelines are needed to help certification authorities identify and evaluate design features that adversely affect pilot performance, awareness of flight hazards, and potential for human error.

Background: Head-up displays HUDs are being installed in air transports for a variety of functions, particularly to increase pilot situational awareness (i.e. out the window) and to enable guided manual low visibility approaches, landings (to RVR 600), rollout (in RVR 400) and takeoffs (in RVR 300). Unique characteristics of head up displays, including collimation, reduced tolerance of non-optimal eye position, overlay of the outside view, display location, and the lack of color, require special attention during certification to ensure airworthiness. While HUD certification criteria has been developed, much of it is based on subjective pilot judgement, rather than objective scientific/engineering data. In order to improve the standardization and validity of the HUD certification criteria, the FAA requires the objective scientific/engineering data and research-based guidelines for evaluating HUDs. Guidelines are needed to help certification authorities identify and evaluate design features which adversely affect pilot performance, awareness of flight hazards, and potential for human error. Particular issues concern information accessibility (clutter), information content, task-display compatibility, display consistency, and physiological (fatigue) effects. Experiments and field studies are to be conducted in iterations with progressive fidelity, where certification guidelines are updated and distributed as the results of each iteration are obtained. The first iteration of studies should resolve issues concerning: 1. The minimal size for the HUD cockpit head motion box. 2. The need for format consistency between head-up and head-down displays. Research concerning clutter should also commence during the first iteration. Int Drv: 2, Red Acc: 3, Ext Drv: 3, New Tech: 4 AVR Ranking: Internal Drivers: USEFUL. HUD certification applicants expect appropriate and practical certification criteria, applied in a standard fashion, and without unnecessary subjective variability. HUD criteria development is not on the AVR business plan. Potential to Reduce Accidents: IMPORTANT. Rapidly changing HUD design and information display offers the potential for significant increases of pilot awareness. However, there is also the potential for pilot confusion, misleading information, distraction and loss of awareness of safety significant conditions.

While HUD's have not been identified as a cause or contributor to civil aircraft accidents, their widespread use in commercial service is increasing dramatically. External Drivers: IMPORTANT. The FAA has been drafting HUD certification criteria, based on past certification experience, ARAC harmonization and SAE technical subcommittee activity. This research is needed to validate and refine this criteria as it is adopted into an official FAA advisory circular. New Technology Impact: ESSENTIAL.

Output:

Regulatory Link:

Requirement ID: 630

Sponsor Organization: AFS POC: Archie Dillard

Requirement Title: HUD Flight Ops. Research

Funded Requirement:
- FY02:
- FY03:
- FY04:
- FY05:

Requirement Statement: Human factors research is needed to provide technical input for certification and regulatory guidance for next generation HUDs.

Background: HUD problems including the following must be examined: clutter/declutter, color usage, symbology shape and content, use and display of primary flight information, reversion, emergency annunciations and display switching. With the next generation of display systems, we will have expanded terrain data bases available, on-board and data linked weather information, expanded synoptic libraries and systems information. The crew will be required to manage the use the display systems, information and communications, to operate the aircraft safely and efficiently in an operational environment that provides less external air traffic oversight and more aircraft. There is universal agreement that the new technologies offer extensive benefits if properly implemented. On new aircraft, designed and built around the new technologies, many of the problems are mitigated by initial aircraft design, but on older aircraft facing retrofit to new cockpits, the problems are compounded. The FAA must take a strong lead in ensuring that the additional cockpit equipment and operational procedures do not cause an unsafe operating environment by impacting flight crew operational awareness and undue workload. The crew must still perform all the basic functions of navigation, communication and operating the aircraft. Tasks included under this project includes the following: Prioritization of displayed data relative to operational mode, or phase of flight. Color usage. Auto-switching and reversion. Head-Up Display (HUD) and head-down display (HDD) commonality. Enhanced vision as displayed HDD or HUD data. The use advanced data display techniques. Use of HUD as primary flight display Use of HUD as sole means flight display. Use of colors on HUD. Use of HUD as a multifunction display. Use of HUD for ground taxi. Use of symbology as an operational replacement for ground infrastructure, such as runway edge lighting, approach lights, edge lights, taxi lights and threshold markings. Integration of precision curved path, or “tunnel”, guidance HUD or HDD, for GPS and Free Flight implementation. This will be a collaborative effort involving AFS, the air carrier industry, equipment manufacturers and others as needed. We all stand to gain a great deal from this effort.

Output:

Regulatory Link:

Requirement ID: 640

Sponsor Organization: AVR POC: Kathy Abbott

Requirement Title: Human Factors Guidelines for Instrument Procedure Design

Funded Requirement:

- FY02: Yes
- FY03: Yes
- FY04:
- FY05:

Requirement Statement: Human factors research is needed to produce a set of human factors guidelines for design of instrument procedures and associated charts that are usable and flyable by appropriately qualified pilots without being susceptible to making errors.

Background: The purpose of this effort is to develop human factors guidelines for design of instrument procedures (and associated charting) to insure that these procedures are usable, easily flyable, and not prone to pilot errors because of design characteristics that do not adequately account for human performance and limitations. This has two aspects: one is the general aspects of instrucment procedures. the second is looking towards the future, and including procedures based on the required naviation performance of the aircraft. In particular, research should address the minimum number of approach plates per runway end, with associated issues of charting, usability, etc. This work will support work being done by AFS400 (Don Pate/Carl Moore) and AVN (Tom Accardi) Desired FAA Outcomes: Reduced CFIT occurrence because of improved instrument procedures and charting. Human factors guidelines and criteria for instrument procedure (and associated chart) design. These guidelines and criteria will be integrated into existing criteria for instrument procedure design and policy. Expected FAA Output: Results from this research study will support improvements in instrument procedure design criteria, including incorporation of new concepts such as RNP for RNAV procedures. Project Performance Goal: Develop human factors guidelines that address known difficulties with use of instrument procedures, and also address future instrument procedure requirements. Program Drivers: (See paragraph 8 above) This activity directly supports implementation of the FAA Human Factors Team Report recommendations (as per AIR business plan), the development of the AFS Human Factors plan (AFS Business plan initiative 5.4) and the Safer Skies JSIT recommendations for CFIT. Criteria: Internal Driver= 4 (based on AVR Performance Plan Appendix A-1 P. 1 initiative #2- Implement CFIT selected interventions- detailed implementation plan; and AFS FY02 plan Initiative 2.13); External Driver= 3; Potential to reduce accidents= 3 (based on CFIT JSIT Outcome #4B & #20); New Technology= 3 Note to Kathy: insert sentences from plans. Also fix up request and products (outcomes).

Output: Guidelines suitable as a basis for inclusion in FAA TERPS/ICAO PANS OPS Guidelines for charting Minimum number of approach plates per runway end (JSIT for CFIT & Appr & Landing) Identify HF issues in moving forward

Regulatory Link: Criteria for inclusion in 8260.3 (TERPS) Criteria for associated charting

Requirement ID: 624

Sponsor Organization: AFS POC: Archie Dillard

Requirement Title: Human Factors in Terminal Area Operations (LAHSO)

Funded Requirement:

- FY02:
- FY03:
- FY04:
- FY05:

Requirement Statement: Human factors research is required to address human performance and risks associated with the implementation of LAHSO.

Background: This research will conduct realistic human factors operational evaluations on FAA initiatives for operational procedures and implementation of new technology through the use of advanced flight simulators at the FAA's advanced simulator facility at the Mike Monroney Aeronautical Center in Oklahoma City, OK, air carrier, industry and other sites. Tasks specifically targeted for work under this project are landing distance, aircraft braking system performance, Flight Operations Assurance Data (FOQA), incident tracking system, validation of the 1000 feet in new LAHSO Advisoy Circular (March 2000) visual vertical guidance, electronic vertical guidance, night operations, rejected landings and take-offs,communications and procedures, air traffic control procedures, and new technology. References to supporting programs/policies: Internal drivers: (4) FAA Strategic Plan: Accident Prevention, Runway Safety Potential to Reduce Accidents: (3) Strategic Plan: Accident Prevention, SaferSkies: Commercial: Approach & Landing, General Aviation:Runway Incursion External drivers: (4) Response to ATA, ALPA, etc pressure to deal with LAHSO New Technology: (3) Safer Skies: Approach and Landing, Pilot decision making, runway incursion.

Output:

Regulatory Link:

Requirement ID: 932

Sponsor Organization: AIR POC: Colleen Donovan

Requirement Title: Human Factors Issues Regarding Airport Surface Information Displays

Funded Requirement:

- FY02: Yes
- FY03: Yes
- FY04:
- FY05:

Requirement Statement: to create a comprehensive reference document that captures all the human factors issues relevant to the design and development of surface map applications

Background: The FAA is charged with approval of a surface map displays for installation and operational use in aircraft. The approval process will require an understanding of how the application will be used by crews and the implications for operational procedures. Aircraft Certification is in need of guidelines and data to help them evaluate human factors issues related to the approval of surface maps displays.

Output: A document on human factors considerations for airport surface information displays.

Regulatory Link:

Requirement ID: 899

Sponsor Organization: AAM POC: Bill Kaliardos

Requirement Title: Human Factors Issues with ADS-B

Funded Requirement:

- FY02:
- FY03:
- FY04:
- FY05:

Requirement Statement: Human factors research is needed to provide guidance for the certification of Automatic Dependent Surveillance Broadcast (ADS-B) systems.

Background: To date the FAA has no published guidance on human factors issues ADS-B systems in order to determine what is acceptable and what is not. This material needs to be data-driven and research is needed to identify potential issues and resolutions. Three major steps are proposed: Step 1: Compile issues list Compile a list of all human factors issues noted for ADS-B avionics from the various certification meetings, Op Eval 1 and 2, issues resolution determination lists from Op Evals 1 and 2, MITRE reviews, and NASA reviews. These should include issues from the notes of Gene Arnold, George Lyddane, Gary Livack, Colleen Donovan, Terry Stubblefield, Oscar Olomos, Randy Bone, Walt Johnson, Vern Battiste, Terry Abbott, Rose Ashford, observers in jump seats, and anyone else who provided evaluation input. Once these issues have been collected, similar issues should be combined and all issues should be clarified to ensure that everyone understands what each issue pertains to. Additionally, issues should be collected from the international evaluations that have been conducted, as well as a general literature search, to identify relevant and potential issues with the avionics pilot interface(s). Step 2: Avionics inventory Compile the following items: 1) a list of all ADS-B avionics products (black box or red box) from each avionics manufacturer; 2) a features list (e.g., knob) for all features on each system; and 3) A functions list (e.g., ability to select target) for all functions on each system. In a chart or table, denote the features and functions for each box. Text paragraphs may be used to elaborate or expand on features and functions. Also, list each “application” that each box does, as well as associated “intended function” statements that manufacturers have applied for (or plan to apply for) to FAA Aircraft Certification and Flight Standards offices. Step 3: Assess specific applications Develop a list of applications for each piece of equipment, beginning with existing approved applications and extending to proposed applications. The intended function of each application should be defined, and initial assessments should be done by human factors specialists. Once these have been completed, human factors specialists should work with pilots to assess the various applications in real-world scenarios under low,

average and high workload environments. All features and functions of the equipment should be fully exercised. Assessments Effects of each of the applications should include, but not be limited to: application on existing pilot/crew workload, including effects observed under Any factors which might limit the low, average and high workload conditions Where and how the applications will use of the avionics for a particular task be used (e.g., terminal, enroute, oceanic, approach, departure, surface Implications and impacts of using the applications in specific movement) Pilot use operational environments (Part 121, Part 135 and Part 91 operators) of ADS-B information on the primary flight display and/or a combination of other Impact on situation Head down time associated with each application displays Use of alerts/warnings in the operational environment, including awareness prioritization, how alerts/warnings should be acted upon, and how they interface Airborne conflict management with the alerts/warnings of other cockpit systems Phraseology that is specific to using ADS-B avionics or is application Procedures for using specific, as well as the impact on ATC communications How the procedures impact/tie into standard operating each application How the applications impact cockpit workflows practices and procedures Pilot/crew roles and responsibilities during various phases of flight with Pilot/crew roles and responsibilities with respect to operating the equipment respect to self-separation Step 4: Certification Policy. The results of this research will be incorporated into guidance material for certification.

Output:

Regulatory Link:

Requirement ID: 893

Sponsor Organization: AIR POC: Glen Gallaway

Requirement Title: Integrated Modular Avionics (IMA)

Funded Requirement:

- FY02:
- FY03:
- FY04:
- FY05:

Requirement Statement: Human factors research is needed to facilitate the identification and resolution of human factors issues with new integrated modular avionics systems, such as the Honeywell Primus Epic IMA system.

Background: Integrated modular avionics (IMA) is a generic term used to describe a distributed real-time computer network aboard an aircraft, such as the Honeywell Primus Epic system. IMA systems are comprised of an avionics rack and modules which contain software functions, such as GPS, autopilot, etc. The IMA systems also propose to use several combinations of new input devices and active systems which have never been approved in isolation, much less integrated. For example, one proposed implementation is to use an interactive electronic checklist with a series of new cursor control devices (joystick, trackball, mouse, etc.). To date we have not approved an interactive checklist (for example, where the system indicates "engine on?" the pilot clicks yes- and the system goes off and starts the engine), much less with a new cursor control system. Additional feedback/labeling issues arise from the new role of the pilot of ensuring the right software/version is installed in the right rack. For example, never before has the pilot been responsible for ensuring the "autopilot module" was installed on the right card in the right slot. Given the number of issues with poor automation feedback/annunciation ("What is the system doing now, what is it going to do next", etc.) with other less automated systems, this is expected to be a major issue which requires some up front research to drive the design and certification guidance material. Thus, these new IMA systems pose many significant challenges from a human factors perspective in addition to those we traditionally think of such as crew skill and workload issues. It is anticipated this research would need to be conducted at a facility that had the ability to mock-up or prototype various implementations of IMA systems and system interfaces so that they might be evaluated. The goal is to have research to identify issues with various versions and implementations of IMA systems, including the associated input devices and integrated systems

Output: The results of this research is intended to mitigate risks associated with the implementation and integration of IMA systems in the aircraft as well as form the foundation for material in the human factors advisory circular (and associated

RTCA document) on IMA. A report containing an industry review (what is being done/proposed by the industry such as the various versions of the Honeywell system), 2) documenting potential human factors issues with IMA systems, controls, and associated aircraft functions (flight control, communications, maintenance, etc. 3) documenting issues and recommendations for feedback requirements (what should be labeled, annunciated etc.) to ensure the pilot is in the loop where appropriate, 4) documenting issues and guidance for evaluating cursor control devices. The report should also include guidelines for evaluating individual IMA systems, control systems, as well as issues across IMA modules and with associated aircraft systems (including flight controls, communications, maintenance).

Regulatory Link: Integrated Modular Avionics Advisory Circular and Technical Standard Order C-153. Input will feed into the AC as well as to the RTCA Special Committee- 200 document on IMA requirements.

Requirement ID: 806

Sponsor Organization: AIR POC: Colleen Donovan- Gallaway

Requirement Title: Multi-function controls

Funded Requirement:

- FY02:
- FY03:
- FY04:
- FY05:

Requirement Statement: Research is needed to facilitate aircraft certification specialists in the identification and resolution of human factors/pilot interface issues with new cursor control/display devices in flight decks, including touch screens, track balls, joy sticks and other implementations being proposed by manufacturers such as Honeywells Primus Epic system. This guidance should include certification minimum requirements and design guidance, based on research and usability assessments of new and emerging multi-function control/display systems.

Background: Aircraft certification specialists are currently being asked to review and approve new integrated modular avionics devices, such as the Honeywell Primus Epic system, which contain complex integrated cursor control/display devices with functionality well beyond what has been approved in the past. Serious potential consequences may arise if these specialists approve something that should not be approved, as some of these systems have cursor control devices controling aircraft systems (engines etc.). To date the FAA has no published guidance on human factors issues with these types of systems in order to determine what is acceptable and what is not. This material needs to be data driven and research is need to identify potential issues and resolutions.

Output: Research report documenting issues and literature review. Recommended certification guidelines

Regulatory Link: Draft new advisory circular on cursor control devices and/or update to Integrated Modular Avionics (IMA) AC.

Requirement ID: 611

Sponsor Organization: AIR POC: Colleen Donovan

Requirement Title: Multi-Function Display/ Controls

Funded Requirement:

- FY02:
- FY03:
- FY04:
- FY05:

Requirement Statement: Human factors minimum requirements and design guidance is needed to update FAA Technical Standard Order (TSO) C113 on multi-function displays. This guidance includes certification standards to be used by aircraft certification specialists reviewing new multi-function avionics with novel features for which no FAA certification guidelines exist including: displays which concurrently multiple information such as display weather, traffic, navigation information etc. Guidance is also needed to support flight standards in determining what types of operational approvals should or should not be grated based on usability of the system, workload issues, etc. Items to be considered: guidelines foreach feature and function of typical MFD's currently on the market and likely to be on the market in the near future (as identified by manufacturers or at public functions such as Oshkosh where they demonstrate prototype systems). Sample research questions: identify issues and potential consequences of various possible combinations such as when you have red traffic on top of red terrain, on top of red weather? What should the FAA approve or certify for use? What happens when you have TCAS and ADS-B alerts being indicated simulatenously- what should our certification requirements be? Additional tasks requested by AFS for potential consideration in FYO3 and beyond: Examine issues and make recommendations for clutter/declutter, color usage, use of display for primary flight information, reversion, emergency annunciations, and display switching. Provide recommendations for prioritization of displayed data relative to operational mode, or phase of flight.

Background: This research will contribute to the revision of FAA Technical Standard Order (TSO) C113 on multi-function displays, which is out of date and in need of revisions based on current technology and information requirements. This is a critical project, which is part of the AIR buisness plan, but it is not currently being adequately supported since SAE G10 is voluntary and the group membership is not adequate. Future research is expected to follow in order to follow-up and provide additional guidance in areas where not enough is known orbased on certification needs (ex. requested for combined system with both TCAS and ADS-B traffic alerts, etc.). Additional Out-year work: Multi-function controls work (controls used for multiple things). Needed- lit review and research on cursor control devices (touch pad, touch screen, track balls, mouse, etc.) and

multi-function controls. Need compliation of best practices and minimum certification standards- inlcuding a list of issues for certificaiton to consider when reviewing these various input devices. Priority Criteria: Internal= 4 (AIR Buisness Plan Item III.A.2 "Submit policy memo on Human factors guidance for RTCA Avionics MOPS and FAA TSO's for AIR coordination." Policy Lead= Colleen Donovan); Potential to Reduce Accidents= 2 (Useful= "The program provides indirect support to accident reduction iniatives and expands the knowledge base in support of accident/incident prevention or mitigation initiatives." Note: it would indirectly support this by having good HF guidance up front- in the product design); External= 3 (Important- The program supports resolution of safety issues required to develop policy as identified in REDAC, ARAC, RTCA, etc, Committees. Note: This policy would be the HF policy for all new avionics TSO's and RTCA documents); New Technology= 3 (Support for new technology= Important- "allows FAA/AVR to respond in a timely fashion with solutions or procedures for expected new technology")

Output: This should not be considered for funding in FY-03 or afterwards. Multi-function controls item split out as a new requirement.

Regulatory Link: TSO C-113

Requirement ID: 616

Sponsor Organization: ASW POC: Frank Bick

Requirement Title: Pilot demographics- GA, Transport, & Rotorcraft

Funded Requirement:

- FY02:
- FY03:
- FY04:
- FY05:

Requirement Statement: Human factors research is needed to determine how well current information on civil aviator characteristics regarding vision, audition, and anthropometrics, compares with display, control, and compartment requirements as specified by existing certification rules for flight decks.

Background: Entails: Literature reveiw and a review of the CAMI Aeromedical Certification Statistical Handbook (over the past 5 years). Examiniation of pilot characteristics regarding anthropometrics, vision, and audition to determine how actual performance abilities compare with display, control, and compartment requirements as specified by existing certification rules for flight decks. Certification requirements and rules need to be broken down in accordance with Part 23, 25, 27, and 29 with repsect ot operating rules (Part 91, 121, 133, 135, and 137) and compare with appropriate operating FARs mentioned in the above sentence. Suggest observing flight deck evaluation during aircraft certification to gain insight to pilot demographic issues pertaining to particular FAR parts, and observing MEOT.

Output:

Regulatory Link:

Requirement ID: 620

Sponsor Organization: ANM POC: Steve Boyd

Requirement Title: Safety assessment

Funded Requirement:

- FY02:
- FY03:
- FY04:
- FY05:

Requirement Statement: Human factors research is needed to provide a method for assessing the crew interface associated with system failures in which compliance with FAR 25.1309 is predicated on pilot performance of specific actions. The method should provide a means for giving incremental certification credit for crew interface designs that foster good pilot performance in response to system failures.

Background: Project Entails: Development of a method for assessing the crew interface associated with system failures in which compliance with FAR 25.1309 is predicated on pilot performance of specific actions. The method should provide a means for giving incremental certification credit for crew interface designs that foster good pilot performance in response to system failures. 14. Project Performance Goal & Benefits: „h Phase I: Analysis of the safety implication of current methods for accounting for pilot performance in safety assessments; Identification of specific cases where current methodologies allowed applicants to take 100% credit for pilot performance but accident data shows that pilot performance is not commensurate with that level of certification credit. Alternative outcome: insufficient safety benefit to justify initiation of Phase II. „h Phase II: Development of an analysis method which can be inserted into and is compatible with current safety assessment methods. This new method will give full credit for current best practices and less credit for crew interfaces and procedures which are less likely to produce good pilot performance in response to system failures. This will provide incentives to applicants to either make the systems inherently reliable or improve the crew interface and/or procedures. ========== AVR Ranking criteria Internal Drivers (Suggested rating: 3) - Supports the AVR General Goal: "Enhance the level of safety in U.S. civil aviation by instituting effective and efficient safety regulations and ensuring compliance with those regulations." - Supports AVR Targeting Performance Area: "Contribute to aviation safety by developing policies and/or standards, programs, and systems to reduce the number of aviation accidents and incidents related to human factors." - Supports AIR initiative: "Implement the FAA Human Factors Plan initiatives." - Supports FAA HF Plan Initiative 1: "Improve flight deck certification regulations and advisory material to address human performance." Potential to

reduce accidents (suggested rating: 3) - Provides a method for accounting for the impact of flight crew interface and procedure design on the likelihood of hazards due to system failure conditions. - The method, if successful, will reduce accidents by requiring improved flight crew interface design or more reliable systems (in order to show compliance with FAR 25.1309), when proposed designs do not adequately support pilot performance in response to failures. - Will provide an additional intervention to employ in resolving certain identified procedural non-compliance problems identified by JSATs. External Drivers (Suggested rating: 2) - This method provides a general method for addressing a class of design-related pilot errors. New technology impact: (Suggested rating: 2) - This method will provide a general improvement to safety assessment methods that will support anticipated new technologies.

Output:

Regulatory Link:

Requirement ID: 900

Sponsor Organization: AIR POC: Bill Kaliardos

Requirement Title: Traffic Displays (ADS-B, TCAS, & Capstone): Display and Alerting Issues

Funded Requirement:

- FY02:
- FY03:
- FY04:
- FY05:

Requirement Statement: Human factors research is needed to provide a capability for certification personnel to evaluate traffic displays and alerts for flight decks in which both TCAS and ADS-B systems are integrated.

Background: ADS-B provides performance advantages over TCAS systems, but the human factors consequences of their coexistence is unclear. ADS-B and TCAS are likely to coexist on many aircraft because TCAS is a requirement, and avionics upgrades will often include ADS-B due to the low cost of its inclusion with other systems such as multi-function displays. For example, developers are already placing ADS-B targets on a TCAS display, and it may be necessary for the symbology to provide a clear distinction between the two target sets, without increasing workload and clutter. Other issues include the integration of TCAS and ADS-B alerts and advisories (both traffic and resolution).

To date the FAA has no published guidance on human factors issues ADS-B systems in order to determine what is acceptable and what is not. Furthermore, there is no guidance for determining what is acceptable for integrated ADS-B and TCAS systems. This material needs to be data-driven and research is needed to identify potential issues and resolutions. Research will include: reviewing literature to understand the current state of human factors knowledge; conducting a review of past and present ADS-B systems; identifying potential errors and consequences with ADS-B systems, identifying issues with ADS-B installed in the same flight deck as a TCAS system (particularly with different alerting algorithms) and their integration; identifying issues with integrating ADS-B and TCAS systems (including alerting and symbology issues); formulating guidance for certification.

A sub-task related to the alerting issues: The objective of this project is to develop and validate criteria for constraining false and nuisance alerts for cockpit displays of traffic information (CDTI), based on what is known about other alerting algorithms (ex. TCAS) and human performance issues with alerting systems, trust, situation awareness and workload.

This research will span a period of three years, with three distinct phases. Each phase may be considered individually for support, but the latter phases will depend on successful completion of the previous phases. Phase 1 and the first year efforts will focus on data gathering and understand how similar issues were solved with other flight deck alerting systems, such as TCAS, enhanced ground proximity warning systems (EGPWS) and wind shear alerts. This phase will include exhaustive review of the certification standards, requirements and guidelines related to false alerts and alerting criteria published in RTCA MOPS and TSOs for the systems mentioned above. The background and basis for the currently published standards should also be examined, as well as research literature pertaining to human performance issues with alerting systems associated with situation awareness, trust, and workload. The interactions of these constructs will also be examined, with an objective of identifying common underlying structures or mechanisms. This will include a review and evaluation of the Aviation Safety Reporting (ASRS) literature associated with TCAS problems, as well as other TCAS issues in order to uncover lessons learned. Special emphasis will be paid to the three “key references” listed at the end of the paper, as a potential means to develop certification standards to enable the evaluation of traffic collision alerting systems (e.g., CDTI ADS-B, TIS, and TCAS). These key reference papers propose the use of Signal Detection Theory (SDT) methodology as a means to evaluate alerting systems and separate the impact of various decision biases. SDT can be used to study the impact of changes to the decision threshold, and also the impact of changes to the a priori base rate events in the real world. The authors of these key references establish the importance not only of high hit rates and low false alarm rates, but also of the importance of high posterior probabilities of a true alarm. Additionally, they also propose a means to access the impact of these changes, despite the fact that only a handful of airplanes are equipped with ADS-B/CDTI systems, and thus it is difficult to determine the base rate information for these events, which is required to determine the posterior probabilities. Thus, one path of pursuit towards objective criteria to evaluating the CDTI alerting system is by attempting to apply the methodologies proposed and developing recommended certification criteria for the alerting systems hit rates, false alarm rates, and posterior probabilities. This methodology may prove effective in developing objective criteria for evaluating the appropriateness of an alerting system on the “trust/use/misuse/abuse” dimension. Additional methodologies and criteria would need to be developed to evaluate the situation awareness and workload dimensions.

Output: 1. Documentation review:

a) empirical human factors results relevant to alerting systems, available in the public domain (journal articles, conference proceedings, and government reports); b) certification standards, requirements and guidelines related to false

alerts and alerting criteria published in RTCA MOPS and TSOs for cockpit alerting systems;

c) comparison of the alerting algorithms of TCAS, CDTI, CA, and URET

d) previous ASRS analyses on alerting system related incidents to determine if yet another ASRS analysis is warranted;

e) literature on human factors certification for guidelines for development of certification criteria for CDTIs;

f) identification of other data sources (e.g., from demonstrations and simulations or from operational environments) that would allow for further examination of relevant human factors issues outside of a laboratory.

2) Examination of the roles of cockpit alerting systems. This subtask will examine the roles of a number of automatic alerting systems (GPWS, TCAS, wind shear alert) and the impact of these on the respective certification criteria of the alerting systems.

3) Development of measures and criteria for collision avoidance system evaluation. This subtask involves a comprehensive evaluation of available measures of machine, human, and human-machine system performance as they pertain to collision avoidance systems, identification of primary and secondary measures, and evaluation of empirical support for the latter. 4) Develop designs and protocols for experiments. Based on findings from the literature review, we will develop experimental designs and protocols aimed at investigation of the most critical issues relevant to human factors certification of CDTIs and to address possible controversies in the alerting system literature.

Regulatory Link: ADS-B/CDTI (Cockpit Display of Traffic Information) Advisory Circular.

Requirement ID: 621

Sponsor Organization: AIR POC: Colleen Donovan

Requirement Title: Vertical Navigation/RNP Displays/ Symbology

Funded Requirement:

- FY02: Yes
- FY03: Yes
- FY04:
- FY05:

Requirement Statement: Human factors research is needed to support development of minimum certification requirements and guidelines for the approval of new moving map displays depicting surface situation awareness, vertical profile navigation information, and required navigation performance. This also includes the need for research to evaluate and identify human factors issues with symbology being proposed for use on these displays to support the ICAO symbology committee intending to standardize these symbols. Minimum certification requirements and guidelines is intended to go into an RTCA SC-181 MOPS, an FAA TSO on moving map RNP/RNAV vertical navigation displays, and the symbology results will feed into an ICAO document.

Background: New moving map displays are being proposed for certification. These displays include information that is for situation awareness. It is important to understand the potential impact of this information on the pilot, as well as determine what certification requirements are appropriate. The research is needed to facilitate aircraft certification specialists in the identifaction and resolution of human factors/pilot interface issues with new moving map displays including required navigation performance displays, vertical profile situation awareness displays, and surface situation awareness (airport surface map) displays being proposed by manufacturers such as Honeywell, Rockwell Collins, Avidyne, Smiths, Sandel, etc. This guidance should include certification minimum requirements and design guidance, based on research and usability assessments of new and emerging display systems.

On-Going Project Entails: Vertical Navigation display work- guidelines and recommended practices for display manufacturers and to certify the equipment. Issue: many avionics vendors are working on developing vertical navigation and/ or 3-D displays- need a literature review of existing material- produce summary guidelines and minimum certification requirements. Research program should entail experimental testing of displays that simultaneously present top down (plan) and side ways (profile) views- similar to the two views on instrument approach charts. Additionally looking at either display mode alone. Look at issues related to Boeing vs. Airbus use of colors when these displays are combined with terrain and/or weather. Pay attention to depiction of RNP

information (RNP bubble, status, and alerting) particularly on vertical dimension. Primarily avionics research to support AIR in the revision of the moving map MOPS/TSO to include requirements for RNP displays with vertical guidance. Provide recommendations for what works and doesn't work in GPS/RNAV/VNAV displays. Multi- year program.

Additional related tasks: Examination and evaluation of depicting ICAO vs. SAE recommended symbology in electronic format. Issues with depicting that symbology on low-end GA displays and also on vertical navigation displays. Discriminability of symbols.

Conduct research to resolve path mode issue in profile displays applied to the RNP environment and develop application to certification tool. Deliverables: Research Report; Certification tool for evaluation of path mode representation in profile navigation displays.

Priority: Priority Criteria: Internal= 3 Human Factors Guidance to support development of RTCA MOPS & FAA TSO on moving map RNP/RNAV vertical navigation display.

Reduce Accidents= 2 (Useful)

External= 3 (Important- The program supports resolution of safety issues required to develop policy as identified in REDAC, ARAC, RTCA, etc, Committees. NOTE: RTCA);

New Technology= 3 (Support for new technology= Important- "allows FAA/AVR to respond in a timely fashion with solutions or procedures for expected new technology")

Output: Industry Review Report. Report documenting results of usability assessment, with human factors/pilot interface issues, requirements and design guidelines.

Regulatory Link: Moving Map TSO and RTCA DO-257 update.

Requirement ID: 619

Sponsor Organization: AIR POC: Colleen Donovan

Requirement Title: Weather Displays

Funded Requirement:

- FY02: Yes
- FY03: Yes
- FY04:
- FY05:

Requirement Statement: Human factors research is needed to develop minimum certification requirements and recommendations for evaluating the depiction of weather information on flight deck displays as well as to develop a certification usability assessment methods/tool.

Background: A plethora of new weather information is being proposed to be depicted in the flight deck that was previously only available on the ground. This includes real-time graphical information such as graphical metars, winds aloft, precipitation, and NEXRAD data. Concerns about how this information is presented, in isolation and combination, have been raised. Questions such as 'when is the data too old and needs to be removed from display, how is the age of the data depicted? Does it need to be depicted? What about merging data of different ages on the same display, different orientations (north-up vs. track up) displayed concurrently? Color issues, symbology issues? Depicting this information concurrently on a display with non-weather data?

Research is needed to identify the current and emerging human factors pilot interface issues and to develop appropriate requirements and guidelines for the Aircraft Certification Specialists who must evaluate and approve these systems. This guidance should include certification minimum requirements and design guidance, based on research and usability assessments of new and emerging weather displays, regardless of the platform (multi-function display systems, electronic flight bag, etc.). *On-Going Project Entails:*

Update to previously submitted industry product review- including review of existing design conventions. Review of draft weather display requirements and recommendations (in DO-267 and FIS-B advisory circular). *Outyear work:*

1) Usbility assessment of avionics to determine current human factors/pilot interface issues with existing and prototype systems, in order to develop minimum certification requirements for the approval of these systems.

Outyear work:

Priority: Internal 3= Imporant= "implement JSITs"

Potential to Reduce: 4= Program responds to immediate aviation issues that have direct operational safety impact and is identified in an approved JSIT. Note: GA Weather JSIT identified the need for weather displays in the cockpit and streamlined certification of these avionics. Recommendation 1: Provide better information to pilots on the location and severity of weather hazard areas, and better methods of using weather information to make safe decisions on how and when to make a flight.

The greatest proportion of fatal, GA weather accidents can be eliminated by implementing the functional group of interventions contained within this recommendation as a group.

; Produce, and make operational, graphical weather information products that show how and when flights can be made safely.

; Improve the PIREP collection / dissemination system with a common database for controllers, pilots, FSS specialists and dispatchers.

Improve certification to accelerate the equipage of GA aircraft with low-cost avionics for data-link display of weather graphics."

External: 2= Useful

New Technology: 4= The program is required to support development of FAA/AVR policy, rules, TSO's, AC's. Note: work required to support new weather display TSO (via RTCA document) and advisory circular. WX will be data linked up. Certification part of Capstone avionics package

Output: 1) Industry review product report. 2) Usability assessment report documenting potential issues. 3) Issues list which certification specialists can use to develop certification issue papers. 4) Edits/recommendations to draft requirements and guidelines (DO-267 and FIS-B Advisory Circular).

Regulatory Link: FIS-B Advisory Circular, new weather displays Technical Standard Order (draft) and RTCA DO-267A (to be referenced by TSO)

Appendix III

Flight Technologies and Procedures Fiscal Year Project Planning

FY03 Proposed Projects

FY04 Proposed Projects

FY05 Proposed Projects

Flight Technologies and Procedures

FY03 Proposed Projects (contract dollars)

Project Title	Performer	Sponsor	Req ID
Airport Surface Information Displays	Volpe	AIR-130	932
Develop Job Aid for Certification (and Design) Personnel	Research Integrations	AIR-100/ANM-111	623
Electronic Aeronautical Chart Symbology	Volpe	AIR-130	621
Electronic Flight Bag	Volpe	AIR-130	639
Error Management	Ohio State University	AIR-100	641
HF Guidelines for Certification of Head-Up Displays	Volpe	ANM-111	633
HF Guidelines for Instrument Procedure Design	NASA Langley	AIR-100	640
Profile Situation Awareness Display	Volpe	AIR-130	621
Weather Displays	CAMI	AIR-130	619

Flight Technologies and Procedures

FY04 Proposed Projects (contract dollars)

Project Title	Performer	Sponsor	Req ID
Develop Job Aid for Certification (and Design) Personnel	Research Integrations	AIR-100/ANM-111	623
Electronic Aeronautical Chart Symbology	Volpe	AIR-13-	621
Flight Deck Alerting	TBD	ANM-111	612
HF Guidelines for Instrument Procedure Design	NASA Langley	AIR-105N	640
Land-and-Hold-Short Operations	TBD	AFS-400	624
Multi-function Displays/Controls	TBD	AIR-130	611
Weather Displays	CAMI/Kansas State University	AIR-130/AFS-400	619

Flight Technologies and Procedures

FY05 Proposed Projects (contract dollars)

Project Title	Performer	Sponsor	Req ID
Develop Job Aid for Certification (and Design) Personnel	Research Integrations	AIR-100/ANM-111	623
Electronic Aeronautical Chart Symbology	Volpe	AIR-13-	621
Flight Deck Alerting	TBD	ANM-111	612
HF Guidelines for Instrument Procedure Design	NASA Langley	AIR-105N	640
Land-and-Hold-Short Operations	TBD	AFS-400	624
Multi-function Displays/Controls	TBD	AIR-130	611
Weather Displays	CAMI/Kansas State University	AIR-130/AFS-400	619